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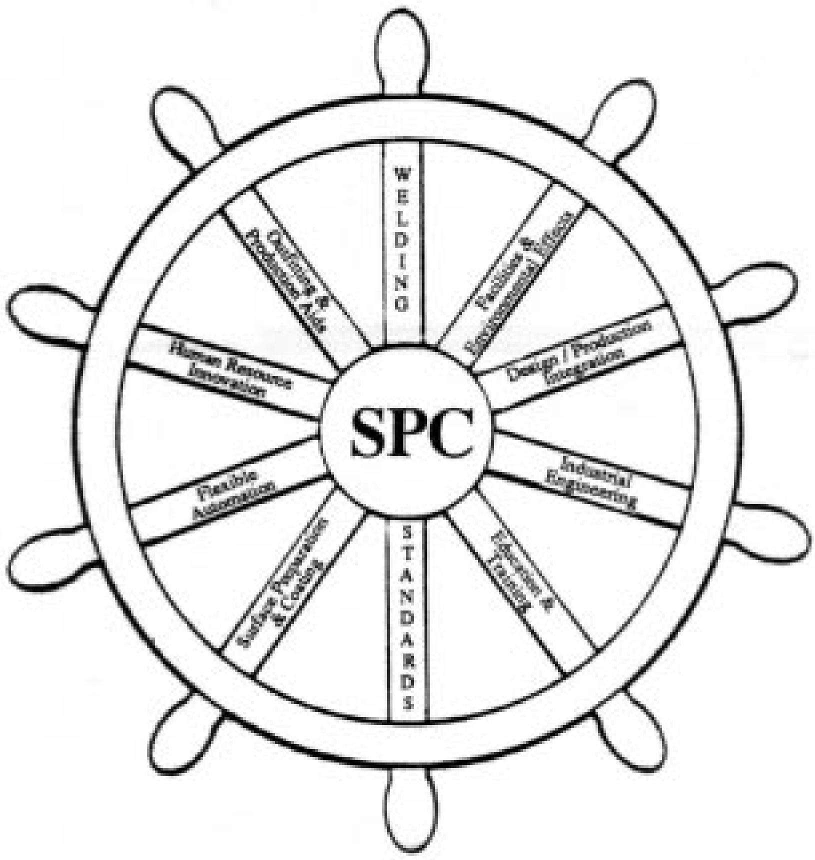
Preparing for the 21st Century: Focusing on Productivity and Quality Management



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Index Based Management Information Systems: A Study in Structured Operations

3A-2

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ABSTRACT

In any job, project, program, or complex undertaking there exists a need to understand all aspects of the work. This understanding is necessary to satisfy all requirements in the most effective and efficient way. The methods available to plan and accomplish these tasks are as vary as much as the tasks themselves. They range from job shop techniques to Material Requirements Planning (MRP) to Project-Based Management Information System (PBMS) to continuous manufacturing. This paper is a critical analysis aimed at classifying two of these system approaches as they relate to the ship repair equation.

Material Requirements Planning (MRP I) tracks a need for material through a project. The production process on the material determines how labor is applied to transform raw materials into finished products. MRP material needs are determined by sales forecast ing. while labor requirements are determined algorithmically from material take-offs. Another form is Manufacturing Resource Planning (MRP II). This form of MRP is a management process, supported by computers, which results in monthly production plans based on sales outlooks, etc., and is far more comprehensive in scope and integration than MRP I.

A complete Project-Based System incorporates the five phases inherent to any project. They are: organize, plan, implement, monitor, and control. The tools necessary to accomplish each of these phases are the heart and soul of a complete project-based Management Information System (MIS). This system approach uses labor as the functional attribute of the work, and ties material, required tools, references and other necessary items to each step of labor.

While both MRP and PBMS have their places in the industrial world, an analysis of the operational capabilities of each is necessary to determine which management system approach suites for the specific application of ship repair. After a detailed analysis of the needs and requirements of the ship repair industry, it becomes clear that a project-based MIS lends itself more closely to the operational requirements seen in the shipyard environment.

A discussion of how and when each type of system would be effective follows. The discussion will include a detailed breakdown of the basic concepts inherent in a PBMS as they relates to ship repair.

To date, most management systems developed revolve around the manipulation of accounting data for delivering processed information to managers. From this data, working decisions are made.

The new generation of project-based management systems, including those in the development phase, use a new index-basing concept. This new concept focuses on all aspects of the organizational and work structure. Only after complete definitions of these structures are defined. and are understood in a meaningful context, can the job requirements be assigned meaningfully and productively to the organization. Information tools are then used for effective execution of the job from a management or production control perspective.

Once the definition of reference structures is accomplished, the next task within this index-based management information system is the connecting of the structures. This is necessary so information can be "hooked" and coordinated into a viable plan for job understanding and later accomplishment. Development of these tools is explored in depth to show the inherent parts from which the PBMS model is derived. The study of structure development and interrelationships, and how the structure is independent of data, are dealt with in conceptual terms. Then, the uses of structures to form a computer-based information system is described.

In conclusion, the case is made for use of a project-based/index-based MIS in all phases of the ship repair industry. Versatility and adaptability are put forth as system attributes which make it an attractive alternative for any management application.

Productivity in the Shipyard Environment

Improving productivity in the shipyard environment can be one of the most challenging management problems. Developing the correct type of management system to deal with the productivity problem is the basis of this paper. This includes, how to do the most with the least, or how to balance customer demands against a limited work force and tight, budgets caused by heavy competition.

To achieve the optimal productivity from a production department there are certain key factors that must be present. Some of these factors are directly controllable and some are beyond the manager's control. The goal must be to handle all factors within the manager's control and reduce the effect of the factors over which he has no control. Productivity involves getting the most work possible out of an organization while maintaining a high level of morale. It also involves continually improving processes to promote the highest quality output.

To maintain a production base. management must make certain decisions about how much work the production work force can accomplish. Sometimes management's expectations of productivity can exceed the maximum productivity achievable. When this occurs production managers must decide how to handle the situation. If the work requirements are temporary, then temporary labor may be part of the solution. In contrast, if the work requirements are going to be a long term, then hiring new employees to fill the requirements may be the answer. In either case there are certain unknowns introduced into the production management equation. One unknown is the real capabilities of the new employees. This can obviously range from marginally capable to highly capable. The manager must then increase the use and productivity of the base work force, while reducing any negative impact resulting from the newly hired employees.

The Management Challenge

The complexity of ship repair and modernization work hinges on the large numbers of interrelated tasks that must occur in the proper sequence. Maintaining an entire work force that is up to date in modern equipment and procedures is a very difficult task. To handle this problem the manager must develop a way to convey the requirements of the job in a form that everyone can understand. Those aspects of the job which are truly the responsibility of management (and not production) must be accomplished correctly before the assignment and execution of waterfront production work. Figure 1 graphically describes the Management Challenge. Management exists to- "close the gap" between worker capabilities and job complexities. Training and automation are only partial solutions. Computers can help in the process but can be an obstacle if improperly employed. Traditionally, most of the expertise that enables the manager to close this gap is gained through experience from years of on-the-job training. What will happen when the seasoned manager leaves the company through attrition or retirement? If he has done his job, there should be a long list of managers ready to take his place. This is not always the case and the company can suffer if this legacy degenerates. One way to capture this expertise and maintain the years of experience without being dependent on any one manager, is through the creation of an "Expert System". The following paragraph describes the positive and negative attributes of the "Expert System" concept as it relates to the ship repair equation.

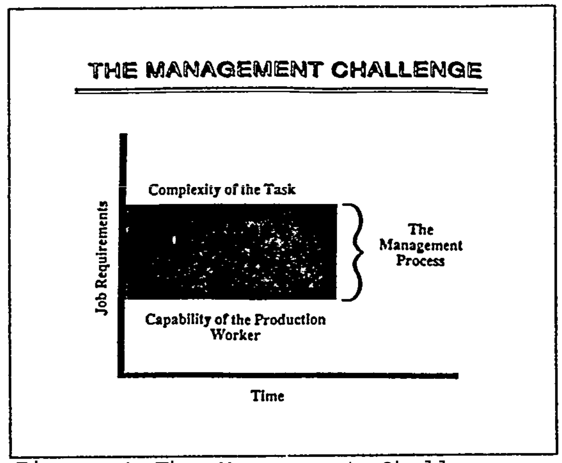

Figure 1 The Management Challenge

The Expert System[1,2]

Expert systems have been under development in some form since the early sixties. The expert system itself has developed as a branch of science dealing with artificial intelligence. Artificial Intelligence (AI) is the field of science dealing with the production of computer software. The software will emulate the thought processes of the human brain. As one can imagine, the complex nature of brain processes pose a large problem for program developers.

An expert is a person who has in-depth knowledge of a subject. He has an in-depth understanding of all of the technical information dealing with the Subject. In the terminology of AI, a person with a strong knowledge of a specific area is the *"domain expert."* The expert has the ability to manipulate all of the data and information in a way to formulate an answer to the problem. By going to an expert you can get a quick answer to your problem. He can provide the information that you need, or get a quick solution for a difficult decision. The expert has gained his knowledge and experience through formal and informal learning as well as experience.

The ship repair industry uses experts in the field help to overcome the difficult and costly situations which impede production. Capturing the knowledge of these experts into a software program, and maintaining that knowledge has significant dividends both for the production effort as well as the training and development of future experts.

The additional benefits of expert systems are far reaching. *Improved productivity* is realized through the use of expert systems. This is realized by putting valuable knowledge at the manager's fingertips so it may be applied when needed. Thus, helping to get the job done more quickly and permitting the accomplishment of more work in the same time frame. The ability to *Preserve valuable knowledge. is* another benefit of Expert Systems (ES). The knowledge of an expert *is* extremely valuable. In most cases it has taken a long time and a lot of effort to accumulate the vast expertise in his field. It is very difficult to price the value of expert advice but, it proves invaluable when used. Packaging the expert's knowledge into a software program can result in a competitive advantage of great benefit in the ship repair industy. A third benefit is, *improved understanding and learning. The* expert system helps managers understand how the expert goes through the decision making process or how his knowledge applies to the problem. The use of expert systems on a regular basis by the manager will allow the manager to become quite familiar with the subject matter. If the manager realizes enough experience through the use of the system, the manager's performance may approach that of an expert.

Knowledge is the heart of all expert systems. Knowledge is the human understanding of a field of interest that is obtained through education and experience. Knowledge is structured information. The relationships between ideas, concepts, facts, figures, theories, procedures is knowledge. Much of the information that experts formulate into knowledge comes directly from a reference book. Examples of information are specialized material properties, math tables, and even a dictionary. By formatting and combining these types of knowledge, an expert system is created. This type of system would not provide the most valuable type of knowledge that the expert could provide. The expert provides *heuristic knowledge,* defined as a practical real-world understanding acquired through years of experience and exposure to many situations and problems.

Information and knowledge should not be confused. The two are used interchangeably but the differences are important. Information is uninterpeted data. Knowledge, on the other hand, is an understanding of the information based on analysis, a realization of its importance, and its applications. Later in this discussion, the use of knowledge vs. information, in developing index based management systems will become clear. The ability to represent the knowledge of the ship repair process in a knowledge base is the most difficult problem for the ship repair manager and system developer.

The field of expert system computing uses a totally different approach to computing than conventional approaches. The system starts with a knowledge of the domain. This knowledge once collected. represented, and stored in a form that a computer can readily use and understand. *This* knowledge is represented symbolically. A symbol is nothing more that a word. letter. or number used to represent objects, actions, and their **relationships. The** computer stores these symbols as ASCII strings. The interrelationship of information, as defined on the symbols represents the *knowledge base.* Once the knowledge base is created then a means of using it is developed. This means is in a program called the *inference program or inference engine. This* program is used to decide and make judgments based upon the symbolic data in the knowledge base. The inferenceing program takes external inputs about the problem and applies the available knowledge to arrive at a solution. Used **in** combination the knowledge base and the inference program are an expert system.

TWO APPROACHES CURRENTLY EMPLOYED FOR PRODUCTION MANAGEMENT SYSTEMS

Two of the diverse system approaches now employed as production management systems in today's ship repair industry, are Project Based Management Systems (PBMS) and Material Requirements Planning (MRP). MRP is a system based on material to which labor applied to manufacture an end product. PBMS uses labor and applies material as necessary to meet the job requirements. In the following paragraphs both types of management systems are discussed.

Material Requirements Planning (MRP)

Material Requirements Planning is a management system that develops the requirements for end products from sales orders and forecasted sales. The system then generates the requirements for the order of raw materials to accommodate the production processes necessary to form the end product. Throughout the production process, from ordering and receiving material to shipping the end product. labor is "tied to material". The demand for the end product initiates a long chain of events necessary to get parts to assemble the end product. The end product, composed of assemblies, which themselves are composed of sub assemblies are joined to form one product. The lead time requirement to order and receive these assemblies is a major part of the calculations necessary in the MRP system.

Material Requirements Planning calculations begin with the *master production schedule* which includes the number of units of each finished product produced in each period. With the information in the master production schedule, one can show when the various parts that make up the final product must be available. The master production schedule receives inputs from sales orders and forecasts. Once the parts are identified a *Bill Of Material (BOM)* is generated. The bill of materials is a structured parts list; however, it differs from an ordinary parts list in that it shows the hierarchical relationship between the finished product and its various parts. A schematic diagram of an MRP information system is shown in Figure 2. Forecasts and orders are used to develop the master production schedule. The master production schedule, Bill Of Materials, and current inventory files are the inputs to the MRP computations.

The output from the MRP computer program is the requirements for each item in the bill of materials along with the dates each item should be available. This information is used to plan order releases for production and purchasing. While the computations for MRP are very extensive, the development of high speed computers has facilitated its usage and development.

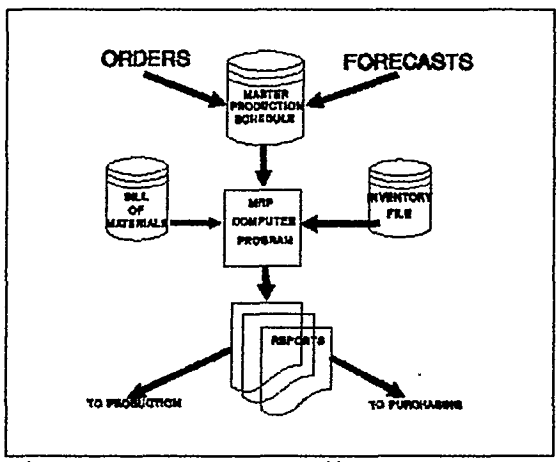

Figure 2 MRP System diagram

Project Based Management Systems (PBMS)

In contrast to the MRP system described above the PBMS uses labor and ties material to the labor element. To implement the PBMS a complete work breakdown structure must be organized and developed. A work breakdown structure consists of an organized approach to doing the job at hand.

One complete description of a PBMS starts with a description of the five (5) basic phases of any project. These phases are organize, plan, implement, monitor, and control. Using these five steps as an outline for the discussion

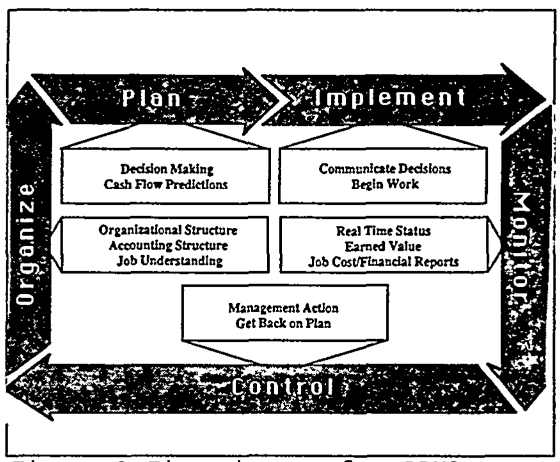

Figure 3 Five phases of a PBMS

of PBMs will show how the system is utilized. Figure 3 graphically represents the five (5) phases included in the PBNS.

Organize

The organizational phase is the most important of the five phases. During this phase, the project is broken down into small, understandable parts called *work elements* thoroughly to understand its scope. Figure 4 shows the work element definition and contents. Work elements are single trade/single operation steps of work. The trades and operations are based on the type of organizational structure and the desired level of managerial detail. The PBMS allows the task to be broken down to single trade - single operation level of detail and tie material and other supporting attributes to each work element. The pay-back of this approach is not only through a Greater understanding of the work, but also later in the management cycle. During the implementation phase. work tasking s made clear and understandable. During the monitoring phase of the project, consistent status information is

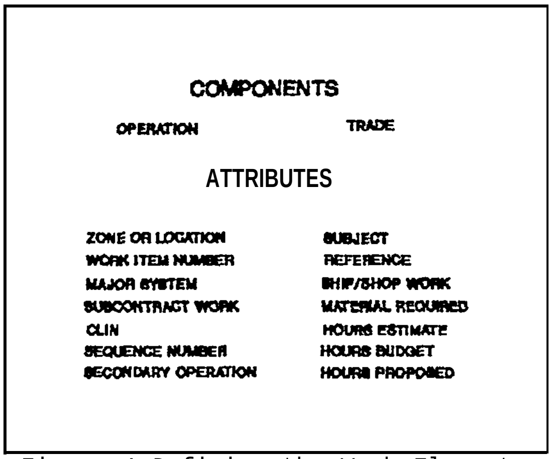

Figure 4 Defining the Work Element

available to make decisions.

Plan

The planning phase involves decision making regarding the who, when, and how work is to be performed. Using the database established in the organizational phase, one can view the scope of the job from many different perspectives to develop logical work packages. Figure 5 shows the various ways to look at work organization. Work packages are developed by trade/functional discipline, customer work item, zone, or type of work operation. "Do-able" work packages are created for production, which include all material, references, schedule, and

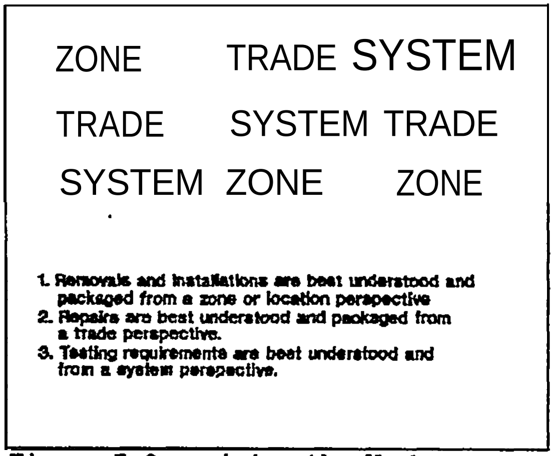

Figure 5 Organizing the Work

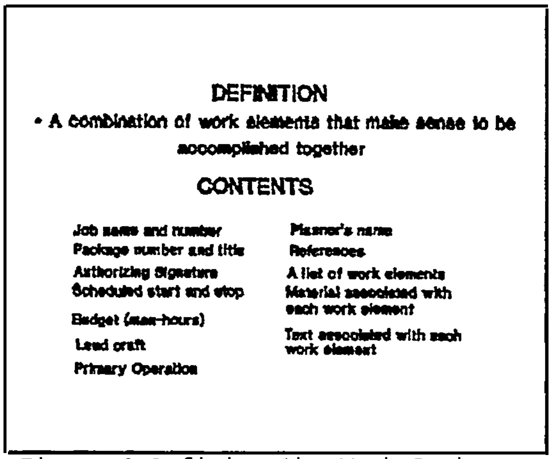

Figure 6 Defining the Work Package

resource information needed to do the task. Figure 6 describes the work package content. PBMS supports the application of group technology in the development of work packages while yet satisfying the progress reporting requirements of the customer. A master schedule is developed for work package starts and completions on an interactive basis to develop a satisfactory fit between customer milestones and labor resources.

Implement

Once scheduling of the Work Packages within the project and organizational guidelines is complete, the project manager is ready to implement the plan. Within the PBMS approach, implementation is a matter of communicating the plan to the functional organization for accomplishment. The project manager communicates the big picture for the project by milestone schedules as well summarized and detailed reports developed from the database. The project manager authorizes the expenditure of funds and communicates the job funds and communicates the job requirements directly with the release of work packages to production. This is in accordance with the master work package schedule developed in the planning phase of the project cycle. PBMS work packages lend efficiency to this phase of the project because of their makeup and because the production workforce is freed from the material expediting, reference hunting, and production planning. tasks that have already been completed in an earlier phase. Rather. the production force can pursue quality workmanship and schedule satisfaction in accordance with the plan.

Monitor

Monitoring a project is a matter of obtaining timely and accurate work progress information. The monitoring base or budget is established in the organizing phase of the project. Assuming a detailed bottom-up budget was developed for each element of the customer's work requirements, a detailed earned value report by functional organization, customer work item, work operation or work zone/location can be generated. Information is generated at the lowest level of detail for analytic purposes or rolled up to higher summary levels for critical management and customer reporting. The basis for monitoring job progress is at the lowest level, the work element level.

Control

Project control requires management action. The PBMS can provide the tools for information processing, exception reporting and fault isolation. To a significant degree, identification of off-norm or out of control conditions to the responsible functional managers will make the project self-regulating. The database developed during the organizational phase contains so many key attributes, the PBMS provides a strong capability for "what-if" scenario analysis. The PBMS is totally integrated and has accessibility throughout the company so everyone is looking at the same information, thereby improving communication. Functional managers can then focus their attention on problems. If necessary thet can take appropriate management action to develop recovery plans to get back on track. This is done without significant input from the project manager. Significant problems can are analyzed and solution scenarios established quickly by the management team, since everyone is reviewing the same data.

COMPARISON OF MRP AND PBMS IN SHIP REPAIR

Both of the management systems described above have their place in business. To show which one is right for the ship repair industry a look at the industry itself is necessary. The repairs made to a ship during one overhaul probably will not occur exactly the same way, if at all, again. The repair is often a one time event in the life of the ship. Also. in general the basic repair job consists of at least 60% labor (and 40% material). It would not be logical to process material as the guiding component in the management system decision when it constitutes only 40% of the repair job. The more logical path is to tie material to the labor portion of the job. The PBMS also provides tools for managing people, and not treating the human component as secondary to the product. PBMS considers material as a tool, however essential, and necessary it is to complete the job. Material is procured as a necessary resource, ordering by lead times for timely delivery to support a process conducted by people (labor).

With the MRP methodology a repetitive cycle of like events and parts is necessary to realize the full benefit of the management system. The MRP system is better suited to a pure manufacturing process due to the repetitive nature of the process itself, while the PBMS is better suited to the shipyard environment.

INDEXING AS AN ORGANIZING TOOL

Considering that PBMS are the most feasible systems to use for the ship repair management system, there are several options that are making the PBMS even easier and more attractive for the repair activity. Indexing has shown itself as a viable organizing tool for many applications. Its adaptability and flexibility make it a very good tool for organizing work in the PBMS arena.

Indexing is the way to apply the "expert system concept" to the ship repair problem without the large investment of time and sometimes unpredictable results of the classical expert system. Developing the index through use of expert relations allows the nodes of the index to be associated in a "smart" fashion.

Development of Structures

Large amounts of data manipulation have been one of the important thing that computers can accomplish. They are capable of manipulating and performing computations to data to show any of the information that the operator needs to know. In today's era of computing, data manipulation is still important. What is more important is the way in which the data is organized. Organizing the structure of the data is where indexing will dramatically change the approach to management and computers in industry. Indexing is a fast and simple way to set up hierarchichal structures to capture relationships. It allows the manager to adapt the organization to changing environments, different business climates and resource levels without expending the time and expense in the hard coding of database management systems and application programs.

The index system should not be confused with database management systems. There are distinct differences. A database management system allows the user to create and manage large files of data. It is often confused with a knowledge base. A database comprises small units of data called records, which comprise individual data elements called fields.

While a record is a unit of data containing facts and figures rather than knowledge, a knowledge base comprises individual chunks of knowledge. One basic form of representing knowledge is a *rule.* A rule describes the outcome of processing data. Another confusion of databases and knowledge bases is the way the programs search the bases to arrive at the desired end product. A database searches the records to arrive at a certain specific item, often with one or more common elements. The search of a knowledge base is conducted to link units of knowledge to form a logical chain of inferences duplicating human reasoning. The output of the database is usually a set of records to which further analysis must be done to define a rational path of action or a decision. The knowledge base and inference pragram's output is supposed to represent the rational path of action or decision without further analysis.

In the world of indexing, there are several terms that require definition before a complete understanding of the entire process is achievable. There are two basic types of indices. The first is the reference index. Its function is to describe the organization of any hierarchy in any business or process. Picture an organization chart of a company as an index with the CEO at the top of the structure and then working down through the organization. The reference index is the most critical of the indicies. They are use by the manager as reference structures to develop a context for job understanding and to develop the second type of index, the variable index. The information contained in the structure of the reference index often serves as the template for the structure of the variable index. It can be a representation of an organization, or a process. The reference indices are maintained by the cognizant individuals in the corporate organization (i.e.. the personnel reference index will be maintained by the personnel manager). Development of the reference indices is how expert system concepts are implemented into the index. All of the relationships of the nodes within the reference indices can be created with expert relations, thus making the reference index a smart index. In this way. the vast knowledge of seasoned shipyard veterans is saved for future use.

The second type of index, the variable index, is the working tool of the manager. Using the reference index as the basis, the manager develops the variable index to fit the requirements of the job at hand. This could be anything from setting up a job to Setting up a structure for a report that used for customer cost reporting. This method of organizing uses several tools to accomplish the development of the variable structure.

The first tool is the "link". The link is the tool which ties a node of reference index together with a node from another reference index to form the variable index. The method of linking is an interactive operation. It can be thought of as a transaction or a bond between the two nodes within references indices. In the PBMS world, development of a work breakdown structure (WBS) would involve linking of a trade or craft of the "personnel reference index" to an operation of the "operation reference index". The link would then hold knowledge that the specified trade will perform the selected operation. This link would form the initial bond to organize the entire work breakdown structure. Links to other installed reference indices would facilitate the completion of the WBS. Other indices which could be part of the reference index library would include but not be limited to the "configuration", and "process". The configuration reference index would contain the entire configuration of the ship type that under repair. It would be a breakdown through a hierarchial structure of every piece of equipment right down to the part level. Each of the parts would have associated with it all the identifying data needed to order or replace any piece as deemed necessary. This index would be self-maintaining once entered. Each time a new part is added such as an alteration addition, the part or assembly is entered into the configuration index. The process index would be a work flow diagram of all the work to he performed. It is basically a template to which the manager can link other reference indices to add trades, operations. and configuration information to the job changes during the production implementation process.

The next tool needed is the "hook". A hook is used to retrieve data elements of a database and for use in the application of the structure. The data that the hook would retrieve would be the variable data on a job such as "hours charged". The data is updated through the various update methods in place to perform these functions, also organized by the index.

The final part of the index system is the inferencing program. This program is independent of the reference or variable indices. This allows an index to change without affecting the way any inference program delivers its output. The inferencing program would only reference the index's top level and then proceed to search the index for the applicable node which contains the information that the inferencing program requires. The ability to change the structure of an organization or process and still maintain the ability to use the same application programs is a new advancement in the MIS world.

Control and Flexibility

The index system as an organizing tool is the most versatile and flexible yet in the field of front end systems to large project management systems. The managers ability to change. reorganize, and alter the structure of the organization without destroying the capability of the downline managers to do their job within the system is now within reach. The ability of the manager to control the structure of the organization in a real time mode has not yet been realized in the marketplace. Seldom has such a revolutionary scheme been introduced into the management world. In the past and perhaps in other organizations, the ability to make changes to the installed management system is dependent on the ability of the programmers to reprogram the hard coded application programs. This process is time consuming and is fast becoming outdated. The index will soon replace many programmers in corporate programming departments.

Innovations in the hardware and software world have made the index a viable reality. In the past, speed and size restrictions were placed on the capability of an application such as the index system. Today those limitations no longer exist. The structure size is only limited by the computer's internal memory and is seldom a consideration.

The graphics interface that the index system uses makes it user friendly and adds the ability to change the system online.

In Conclusion

The PBMS is the best solution to the management system problem within the shipyard environment. Its ability to facilitate the organization, planning, implementation, monitoring and controlling of the ship repair problem is the key to improving productivity. The extra effort spent in orgainzing the work in the planning phase is more than recouped in the production phase through increased productivity due to better job organization through better job understanding.

The flexibility of the indexing system allows it to be used as the front end processor, not only on project systems such as the PBMS but also on accounting, personnel, and procurement applications. It has shown itself as a viable too1 for organizing just about any function currently used in any organization. The adaptability allowed by creation of the reference indices to suit the operations will allow the index based management information system to be used throughout the spectrum of applications within the corporate world.

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